Efficient Irrigation for Reduced Non-Point Source Pollution from Low Desert Vegetables.

FREP Contract # 98-0423

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Introduction

Efficient water management remains a high priority in the southwestern United States. While the scarcity of water is a major impetus for improving water use efficiency in agriculture, inefficient irrigation practices are also a factor in water quality related issues. The influence of irrigation practices on salt loading of surface waters has long been recognized. Abundant evidence from southern California and Arizona indicates irrigation practices are a significant factor contributing to N losses from soils used for vegetable production. Recent data from Arizona showed that as irrigation levels increased above the amount required to replace evapotranspiration, N leaching below the root zone increased and crop recoveries of N decreased.

There is a tendency for vegetable growers to apply generous amounts of water to produce because of anxiety about crop quality and the lack of sufficient information to do otherwise. Additionally, concerns about salt accumulation having an adverse affect on land sustainability often prompts growers to employ a generous leaching requirement. A perceived lack of practical technologies on irrigation scheduling is another major obstacle to progress in implementing efficient irrigation practices. It is the opinion of the authors that once efficient scheduling and water management strategies are confirmed and demonstrated to vegetable growers in the desert, progress in efficient irrigation will be hastened. However, it is of the utmost importance to show growers that this can be

achieved without compromising crop yield and quality and long-term land sustainability. The first phase of this project experimentally evaluated irrigation scheduling technologies and management practices. The second phase of this project included demonstration of the use of these technologies.

Objectives

(1) Evaluate and develop irrigation scheduling criteria for lettuce and melons produced in the low desert and evaluate the influence of irrigation and N fertilization on crop growth, crop N nutrition and N leaching.
(2) Conduct an outreach program aimed at promoting and implementing efficient irrigation practices.

Description

Over 99% of all lettuce and a significant percentage of the melons produced in the desert are furrow irrigated and studies focused on the development of efficient furrow irrigation practices. However, because some of vegetable acreage, particularly melons, has been converted from furrow to buried drip, studies were also conducted with drip irrigation.

Evaluation of management allowable depletion (MAD) values and crop coefficients (kc) for furrow irrigated lettuce and melons

Experiments were conducted during 1999, 2000, 2001, and 2002 to evaluate "management allowable depletion" (MAD) values and crop coefficients (kc values) for furrow irrigated lettuce and melons. Treatments were selected such that irrigations were applied at MAD values ranging from 20 to 80% depletion of available soil water (SWD). Neutron probe access tubes were installed to a depth of 1.5 m in all plots. Soil moisture measurements were made two to three times weekly. Irrigation was applied to all replications of a treatment when the mean SWD of the treatments reached the targeted SWD. Growth and yield data were collected so that we could identify MAD values associated with maximum crop production. Data from the treatments receiving optimal irrigation were used to calculate kc values from ET as measured by soil water depletion and penmen ET^o values.

Evaluation and demonstration of irrigation scheduling for lettuce

Studies were established in 2000, 2001, and 2002 to evaluate and validate irrigation scheduling for lettuce. The first and third experiment evaluated three irrigation regimes and five N rates. The irrigation regimes were grower standard practice, irrigation based on frequent neutron probe measurements, and irrigations based on weather based irrigation scheduling program (AZSCHED). The N rates ranged from 0 to 250 kg/ha. Information for MAD and kc values utilized in AZSCHED were determined or validated in studies described in the previous section. The second experiment evaluated the three aforementioned irrigation regimes but did not include N rates.

Design and Management Guidelines for furrow irrigated desert vegetable production units

We have come to realize that irrigation scheduling alone will not result in efficient irrigation practices. Therefore, we initiated studies aimed at optimizing system variables for furrow- irrigated vegetables. The development of a management package for the furrow irrigated vegetable production units of the low desert area had been undertaken in four stages: (1) experimental studies (1998-2000), (2) model calibration and validation (2000-2002), (3) simulation experiments and development of management tools [i.e., performance charts and lookup tables (2001-2002)], and (4) development of management guidelines that facilitate effective use of the management tools (2001-2002). The primary objective of the field experimental study was to develop a complete database that would be used in the modeling studies (i.e., model calibration and validation). Models were calibrated by field experiments using volume-balance based parameter estimation models. These models were validated with independent data sets. Simulation experiments with the validated models were used to develop management guidelines.

Drip irrigation for lettuce and melons

Studies were established to evaluate irrigation scheduling approaches for drip irrigated vegetables. This particular experiment focused on evaluating crop coefficients and the interaction between N management and irrigation management. Treatments were four irrigation regimes ranging from 0.2 to 0.8, Penman ET^o values. These treatments were in factorial combination with 3 nitrogen fertilizer treatments. Daily irrigations were computed from average ET^o values as calculated from the previous week weather data. The influence of irrigation regimes on growth and yield were determined from weekly measurements of plant growth and dry matter accumulation as well as marketable yields at maturity.

Results

Evaluation of management allowable depletion (MAD) values and crop coefficients (kc) for furrow irrigated lettuce and melons

Data from these studies suggest using a MAD of 35 to 40% depletion of available water to a 0.3 m soil depth as a basis for scheduling irrigations for lettuce. Crop evaporation (ETc) estimates from several experiments and Penman generated reference evaporation (ET^o) values indicate that crop coefficients for lettuce are approximately 0.1 early in the season (six to eight-leaf stage) and increased to 0.7 during the rapid growth period (after cupping). Data for melons suggest a MAD of 40% depletion of available water to a 0.6 m soil depth. Data for crop coefficients for melons are currently being analyzed.

Evaluation and demonstration of irrigation scheduling for lettuce

Lettuce yields were generally not affected by irrigation regime in 2001 indicating that irrigation scheduling would not compromise yield compared to grower standard practices. In fact, grower practices resulted in reduced yield compared to irrigation scheduling in 2002. During both years, crop yield and crop N uptake responses to N rate

were minimal indicating that residual N was high on this sites used in these experiments. Residual N as measured by soil analysis and N leaching as measured by resins increased with N rate.

Design and Management Guidelines for furrow irrigated desert vegetable production units

This study included field and modeling components. Field experiments were used to calibrate and validate models. Inputs for a surface hydraulic model were measured directly or calculated using surface irrigation parameter estimation models. Models were validated using independent data sets by comparing observed and predicted irrigation advance. Simulations using the validated models were used to develop performance charts and look-up tables for the selection of efficient irrigation practices. Substantial improvements in irrigation application efficiencies and distribution uniformities would be realized using the proposed management guidelines. The suitability of these performance charts was further validated in demonstrations performed during 2002.

Drip irrigated lettuce and melons

For lettuce and melons, optimal yields were achieved at irrigation regimes appreciably below ET^o estimates. Melons appeared to derive appreciable amounts of water from capillary movement from lower soil depths.